6th International Planetary Probe Workshop
June 21-27, 2008 :: Atlanta, Georgia, USA
IPPW-6

PROOF OF CONCEPT OF AN ADVANCED SUN PHOTOMETER FOR PLANETARY APPLICATIONS

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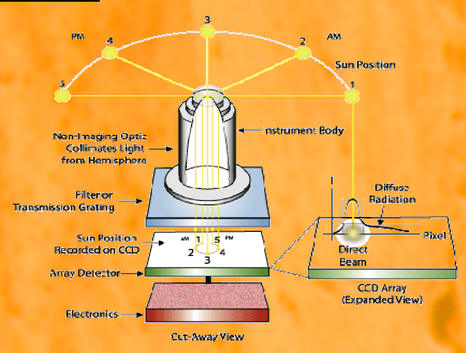


Above: Conceptual diagram of the sun photometer
Left: Sequence of images along an hemispheric meridian with the sun at increasing angles relative to the instrument axis (non-imaging optics)

Background

- Dust is a major driver of the radiative balance and dynamics of the Martian atmosphere at every spatial scale (*Smith, 2008*)
- Dust aerosols found between 0-30 km, τ_{vis}~ 0.4, aphelion season (*Clancy et al.,2007*)
- Water ice aerosols found between 15-45 km, τ_{vis}~ 0.2, aphelion season (*Clancy et al.,2007*)
- CO_2 and/or water ice aerosols found in a distinct layer between 60-100 km equatorial regions, τ_{vis}~ 0.01, aphelion season (*Clancy et al., 2007, Montmessin et al., 2006, 2007*)
- Dust dominates the UV/VIS extinction
- Determining the characterization and distribution of Martian aerosols is essential to
  - the understanding Martian climatology and weather
  - the modeling of Martian dust and cloud dynamics
  - the development of future Mars inhabited and uninhabited missions

Clancy, R. T., Wolff, M. J., Whitney, B. A., Cantor, B. A., & Smith, M. D. (2007). Mars equatorial mesospheric clouds: Global occurrence and physical properties from Mars Global Surveyor Thermal Emission Spectrometer and Mars Orbiter Camera limb observations. *J. Geophys. Res., 112*, E04004, doi:10.1029/2006JE002805.
Montmessin, F., Bertaux, J.-L., Quémerais, E., Korablev, O., Rannou, P., Forget, F., et al. (2006). Subvisible CO_2 ice clouds detected in the mesosphere of Mars. *Icarus, 183*, 403-410.

Instrument Properties

Appropriate for surface measurements on planetary bodies with sensible atmosphere

- Compact
- Lightweight
- Reliable with no or few moving parts
- No sun tracking mechanism required
- Robust
- Low power consumption

Instrument Design

- Uses CCD array detector
- Measures direct and diffuse solar irradiance
- Hemispherical field of view (2π steradian)
- Wavelength dependence determined by:
  - a filter-wheel with interference filters,
  - an acousto-optic tunable filter, and/or
  - a grating spectrometer
- UV/VIS/NIR/IR wavelength capable
- Self-calibrating using Langley method

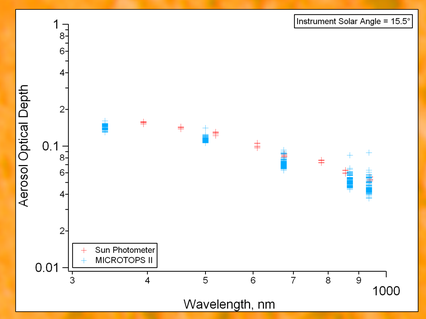
Science Objective

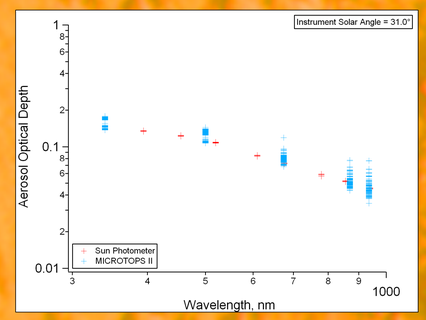
- Characterize atmospheric aerosols (dust, water ice, and CO_2 ice)
- Measure diurnal/seasonal aerosol loading
- Measure diurnal/seasonal trace gas concentrations (water vapor and ozone)
- Determine aerosol size distribution
- Determine downwelling radiative flux
- Obtain ground measurements complimentary to orbital measurements

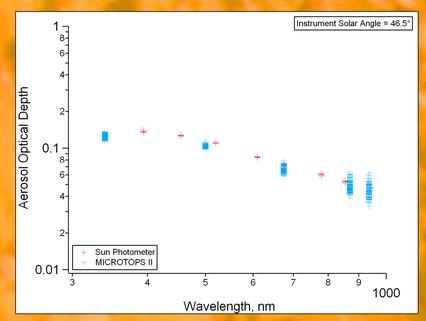
Advantages of Surface-based Measurement

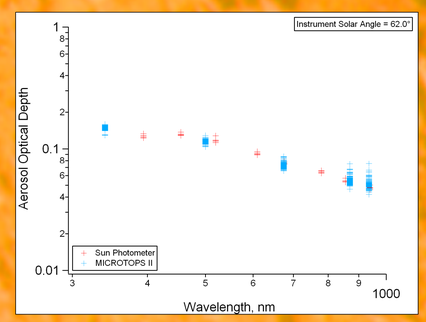
- Continuous diurnal cycle measurement
- Continuous seasonal cycle measurement
- Little affected by surface albedo and phase function uncertainties

Montmessin, F., Gondet, B., Bibring, J.-P., Langevin, Y., Drossart, P., Forget, F., et al. (2007). Hyperspectral imaging of convective CO_2 ice clouds in the equatorial mesosphere of Mars. *J. Geophys. Res., 112*, E11S90, doi:10.1029/2007JE002944.
Smith, M. D. (2008). Spacecraft observations of the Martian atmosphere. *Ann. Rev. Earth Planet. Sci., 36*, 191-219.



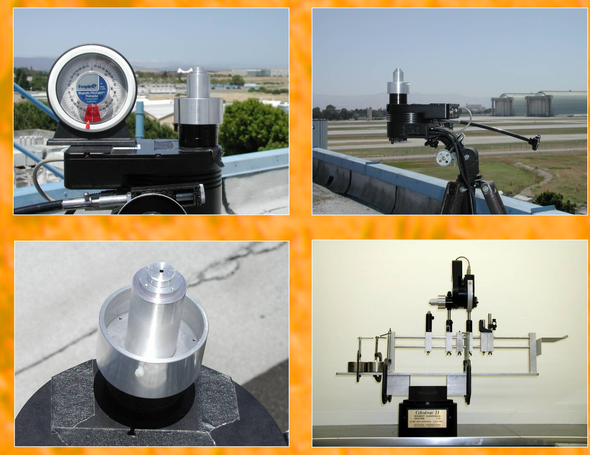






Data Products

- Aerosol optical depth (AOD) as a function of wavelength
- Ice haze/cloud optical depth
- Gas phase columnar abundance (H_2O and/or O_3)
- Direct solar downwelling flux
- Hemispherical downwelling flux
- Aerosol size distribution (r_{eff} and v_{eff})



Above: (clockwise from top, left) Image indicating the compact size of the optical head; Instrument in the field mounted on an small equatorial tripod; Sun photometer mounted on an optical bench; Close up view of the optical cone
Left: Comparison of aerosol optical depths (AOD) measured by this instrument with values obtained using a Microtops II sun photometer. The spread in the Microtops data may be due to atmospheric variability and sun tracking errors.

Conclusion

The measured AOD curves closely match the curves obtained by a commercial sun photometer, indicating this instrument concept can determine optical depths in a near hemispherical field of view without mechanically tracking the sun.